UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/679,031	10/03/2003	Satoshi Komiya	90738	1669

24628 7590 11/29/2005

WELSH & KATZ, LTD
120 S RIVERSIDE PLAZA
22ND FLOOR
CHICAGO, IL 60606

EXAMINER	
SONG, MATTHEW J	

ART UNIT	PAPER NUMBER
1722	

DATE MAILED: 11/29/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No. 10/679,031	Applicant(s) KOMIYA ET AL.	
	Examiner Matthew J. Song	Art Unit 1722	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *14 September 2005*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *4,5,8,9,13-18,22,25-33 and 36-43* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *4,5,8,9,13-18,22,25-33 and 36-43* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

DETAILED ACTION

Claim Rejections - 35 USC § 112

1. The following is a quotation of the first paragraph of 35 U.S.C. 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

2. Claim 4 is rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention. Claim 4 recites, "wherein the nitrogen and oxygen concentrations make a second line from the shoulder portion to the tail portion of the silicon single crystal ingot substantially parallel to the first straight line" in the last two lines. There is no support in the original disclosure for a second line substantially parallel to the first line. The original disclosure only teaches two line in Fig 4.

3. Claim 8 is rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention. Claim 8 recites, "the nitrogen and oxygen concentration along a longitudinal direction of the silicon ingot vary in accordance with a second line in a graph in which the oxygen concentration and the nitrogen concentration are plotted along the horizontal axis and the vertical axis of the graph,

respectively, substantially parallel to a first straight line. There is no support in the original disclosure for a second line substantially parallel to a first line for the concentration of silicon and nitrogen along the longitudinal direction of the ingot. The original disclosure only teaches two line in Fig 4.

4. Claim 14 and 37-39 are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention. Claim 14 recites, "on or above a third straight line which is substantially parallel to the first straight line and passes a point at which the nitrogen concentration is $1x10^{14}$ atoms/cm^3 when the oxygen concentration is $7x10^{17}$ atoms/cm^3" in the last four lines. There is no support for a third line, as claimed, in the original disclosure. The original disclosure only teaches two line in Fig 4. Likewise for the third claimed line of claim 37-39.

5. Claim 15 is rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention. Claim 15 recites on or above a fourth straight line which is substantially parallel to the second straight line and passes a point at which the nitrogen concentration is $3x10^{14}$ atoms/cm^3 when the

oxygen concentration is $7x10^{17}$ atoms/cm^3. There is no support for a fourth line, as claimed, in the original disclosure. The original disclosure only teaches two line in Fig 4.

6. Claim 17 is rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention. Claim 17 recites, "a fourth line which is substantially parallel to the first straight line and passes a point at which the nitrogen concentration is $3x10^{14}$ atoms/cm^3 when the oxygen concentraton is $7x10^{17}$. There is no support in the original disclosure for a fourth line. Figure 4 only teaches two lines and neither support this limitation.

7. Claim 18 is rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention. Claim 18 recites, "a third straight line which is substantially parallel to the second straight line and passes a point at which the nitrogen concentration is $1x10^{14}$ atoms/cm^3 when the oxygen concentration is $7x10^{17}$. There is no support in the original disclosure for a third line. Figure 4 only teaches two lines and neither support this limitation.

8. Claim 30 is rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention. Claim 30 recites, "on or above a horizontal straight line on which the nitrogen concentration is $1x10^{13}$ atoms/cm^3, and between vertical straight lines on which the oxygen concentrations are $9x10^{17}$ atoms/cm^3 and $1.6x10^{18}$, respectively" in the last four lines. There is no support for the vertical and horizontal claimed lines. There is no support for these limitations in Figure 4.

9. Claim 31 is rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention. Claim 31 recites, "on or above a horizontal straight line on which the nitrogen concentration is $1x10^{14}$ atoms/cm^3, and between vertical straight lines on which the oxygen concentrations are $9x10^{17}$ atoms/cm^3 and $1.6x10^{18}$, respectively" in the last three lines. There is no support for the vertical and horizontal claimed lines. There is no support for these limitations in Figure 4.

10. Claim 32-33, 36-37, 40-41 and 43 are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the

claimed invention. Claim 32 recites, "on or above a horizontal straight line on which the nitrogen concentration is $1x10^{13}$ atoms/cm^{3}" in lines 9-10. There is no support for the horizontal line. There is no support for this limitation in Figure 4. Likewise the horizontal line in claim 33, 36, 37, 40-41, 43.

Claim Rejections - 35 USC § 103

11. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

12. Claims 4-5, 8-9, 13-18 and 30-41 are rejected under 35 U.S.C. 103(a) as being unpatentable over Wijarankula (US 5,961,713) in view of Graef et al (US 5,935,320) or Tamatsuka et al (US 6,162,708). 1-18 and 30-41

Wijarankula discloses a silicon substrate **12** with a diameter of approximately 200 mm and includes a boron dopant of $3x10^{18}$ atoms/cm^3 and approximately 23 ppma oxygen. Wijarankula also discloses using semiconductor silicon substrates and epitaxial layers having wide ranges of thicknesses, dopants and dopant concentrations (col 4, ln 10-43). Wijarankula also discloses a typical microdefect **14** with a diameter greater than 0.1 micrometer (100 nm), this reads on applicant's LPDs, and growing a single crystal by the Czochralski method and slicing an ingot into semiconductor silicon wafers (col 4, ln 44-67). Wijarankula also discloses a process step **46** for depositing an epitaxial layer, where the epitaxial layer forms a microdefect-free layer **16** and the concentration of microdefects **14** decreases over a finite transition region **30** from a relatively high concentration in the substrate bulk to approximately zero (col 5, ln 1-67, col 6, ln 1-40 and Figs 2-3), this reads on applicant's LPDs of 120 nm ore more is 20 pices/200 nm wafer or less.

Wijarankula does not disclose a substrate doped with nitrogen.

In a process for forming silicon semiconductor wafers, note entire reference, Graef et al teaches preparing a silicon single crystal having an oxygen concentration of at least $4x10^{17}/cm^3$ and a nitrogen doping concentration of at least $1x10^{14}/cm^3$ and processing the silicon single crystal to form silicon wafers with a low defect density (col 2, ln 40-67). Graef et al also teaches a single crystal produced according to the Cz method and processed to form silicon wafers comprising a nitrogen concentration of $3x10^{14}$ /cm^3 and an oxygen concentration was $9x10^{17}/cm^3$ (col 5, ln 45-60), this reads on applicant's range of nitrogen and oxygen concentration in the silicon wafer substrate falls within an overlapping area in a graph in which the oxygen concentration and the nitrogen concentration are plotted along the horizontal axis and the vertical

axis of the graph, respectively, on or below a first straight line connecting a point at which the nitrogen concentration is $3x10^{15}$ atoms/cm^3 when the oxygen concentration is $7x10^{17}$ atoms/cm^3 and a point at which the nitrogen concentration is $3x10^{14}$ atoms/cm^3 when the oxygen concentration is $1.6x10^{18}$ atoms/cm^3 and between vertical straight lines on which the oxygen concentration is $9x10^{17}$ atoms/cm^3 and $1.6x10^{18}$ atoms/cm^3, respectively because the concentrations for oxygen and nitrogen taught by Graef et al are within the claimed range. Graef et al also teaches the proportion of large defects decreases greatly with the increase in the degree of nitrogen doping (col 6, ln 10-20 and Example 2). Graef et al also teaches the effect of doping the single crystal with nitrogen in terms of defect size distribution must also be considered in connection with the doping of the single crystal with oxygen and for the same nitrogen doping, the proportion of small defects increases as the oxygen doping decreases (col 3, ln 40-45). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Wijarankula with Graef et al's nitrogen doped silicon substrate to reduce larger defects in the silicon substrate wafer.

In a process for forming an epitaxial silicon wafer, note entire reference, Tamatsuka et al teaches an epitaxial silicon single wafer characterized in that a silicon single crystal ingot which nitrogen is doped is grown by the Czochralski method and the resultant silicon single crystal ingot is sliced to produce a silicon single crystal wafer and then a epitaxial layer is formed in the surface layer portion of the resultant silicon single crystal wafer (col 2, ln 1-15). Tamatsuka et al also teaches when the nitrogen concentration of the silicon single crystal wafer is $1x10^{13}$ to $1x10^{14}$ atoms/cm3, it is possible to decrease the defect density on the surface of the epitaxial layer (col 4, ln 1-67). Tamatsuka et al also teaches an oxygen concentration less than18 ppma

($9x10^{17}$ atoms/cm^3) (col 7, ln 40-45 and col 11, ln 30-35). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Wijarankula with Tamatsuka's nitrogen doped silicon wafer to decrease the defect density on the surface of an epitaxial layer.

The combination of Wijarankula and Tamatsuka et al does not teach the range of nitrogen concentration and oxygen concentration falls within an area in a graph in which the oxygen and nitrogen concentrations are plotted along the horizontal axis and vertical axis of the graph, respectively, on or below a straight line connecting a point at which the nitrogen concentration is $3x10^{15}$ atoms/cm^3 when the oxygen concentration is $7x10^{17}$ atoms/cm^3 and a point at which the nitrogen concentration is $3x10^{14}$ atoms/cm^3 when the oxygen concentration is $1.6x10^{18}$ atoms/cm3. Graef et al teaches the effect of doping the single crystal with nitrogen in terms of defect size distribution must also be considered in connection with the doping of the single crystal with oxygen and for the same nitrogen doping, the proportion of small defects increases as the oxygen doping decreases (col 3, ln 40-45), this is a teaching that the relationship between the oxygen and nitrogen doping concentration is a result effective variable. Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Wijarankula and Tamatsuka et al by optimizing the nitrogen and oxygen concentration to obtain same by conducting routine experimentation of result effective variables to minimize large defects. Furthermore, the selection of reaction parameters such as temperature and concentration is obvious (In re Aller 105 USPQ 233, 255 (CCPA 1955)).

Furthermore, the combination of Wijarankula and Tamatsuka et al also teaches oxygen and nitrogen concentration ranges, which overlap the claimed range. Overlapping ranges are held to be *prima facie* obvious (MPEP 2144.05).

Referring to claim 4, the combination of Wijarankula and Tamatsuka et al and combination of Wijarankula and Graef et al does not teach the oxygen concentration and the nitrogen concentration are adjusted in a manner that the oxygen concentration and the nitrogen concentration have a predetermined correlative relationship of the nitrogen concentration increase corresponding to the oxygen concentration decrease and the nitrogen concentration decrease corresponding to the oxygen concentration increase such that the epitaxial silicon wafer has sufficient gettering sites. Graef et al teaches doping the single crystal with nitrogen in terms of the defect size distribution must also be considered in connection with the doping of the single crystal with oxygen and for the same nitrogen doping. Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Wijarankula and Tamatsuka et al and combination of Wijarankula and Graef et al by optimizing the oxygen concentration in relation to the nitrogen concentration to obtain same by conducting routine experimentation of result effective variables because a connection with the oxygen concentration to the nitrogen concentration is known. The fact that applicant has recognized another advantage which would flow naturally from following the suggestion of the prior art cannot be the basis for patentability when the differences would otherwise be obvious. See *Ex parte Obiaya*, 227 USPQ 58, 60 (Bd. Pat. App. & Inter. 1985).

13. Claims 4-5, 8-9 and 35-41 are rejected under 35 U.S.C. 103(a) as being unpatentable over Graef et al (US 5,935,320).

In a process for forming silicon semiconductor wafers, note entire reference, Graef et al teaches preparing a silicon single crystal having an oxygen concentration of at least $4x10^{17}/cm^3$ and a nitrogen doping concentration of at least $1x10^{14}/cm^3$ and processing the silicon single crystal to form silicon wafers with a low defect density (col 2, ln 40-67). Graef et al also teaches a single crystal produced according to the Cz method and processed to form silicon wafers comprising a nitrogen concentration of $3x10^{14}$ $/cm^3$ and an oxygen concentration was $9x10^{17}/cm^3$ (col 5, ln 45-60), this reads on applicant's range of nitrogen and oxygen concentration in the silicon wafer substrate falls within an overlapping area in a graph in which the oxygen concentration and the nitrogen concentration are plotted along the horizontal axis and the vertical axis of the graph, respectively, on or below a first straight line connecting a point at which the nitrogen concentration is $3x10^{15}$ atoms/cm^3 when the oxygen concentration is $7x10^{17}$ atoms/cm^3 and a point at which the nitrogen concentration is $3x10^{14}$ atoms/cm^3 when the oxygen concentration is $1.6x10^{18}$ atoms/cm^3 and between vertical straight lines on which the oxygen concentration is $9x10^{17}$ atoms/cm^3 and $1.6x10^{18}$ atoms/cm^3, respectively because the concentrations for oxygen and nitrogen taught by Graef et al are within the claimed range. Graef et al also teaches the proportion of large defects decreases greatly with the increase in the degree of nitrogen doping (col 6, ln 10-20 and Example 2). Graef et al also teaches the effect of doping the single crystal with nitrogen in terms of defect size distribution must also be considered in connection with the doping of the single crystal with oxygen and for the same nitrogen doping, the proportion of small defects increases as the oxygen doping decreases (col 3, ln 40-45).

Graef et al also teaches oxygen and nitrogen concentration, which overlap the claimed ranges. Overlapping ranges are held to be *prima facie* obvious (MPEP 2144.05).

Referring to claim 4, Graef et al does not teach the nitrogen concentration increase gradually from a shoulder portion to a tail portion of the silicon single crystal ingot whereas the oxygen concentration decreases gradually from the shoulder portion to the tail portion. However, this feature is inherent to doped crystals pulled using the Czochralski method, as evidenced by Applicant's disclosure. Applicant's teach that when a silicon ingot is pulled from a silicon melt, unless the oxygen concentration, etc., is deliberately controlled, fluctuation of the nitrogen concentration caused by nitrogen segregation and fluctuation of the incorporated oxygen concentration resulting in a gradually increasing nitrogen concentration and a gradually decreasing oxygen concentration, note page 6, lines 15-25 of the instant specification. Graef et al does not teach any deliberate control of the oxygen or nitrogen concentration during the pulling process; therefore the gradually increasing nitrogen concentration and gradually decreasing oxygen concentration is inherent.

Referring to claim 5, Graef et al does not teach the nitrogen concentration in the tail portion is set less than $3x10^{15}$ atoms/cm^3. Graef et al teaches pulling a silicon ingot using the Czochralski method, which inherently includes a tail region, with a nitrogen concentration of at least $1x10^{14}$ cm^3, which overlaps the claimed range. Overlapping ranges are held to be *prima facie* obvious (MPEP 2144.05). Furthermore, control of nitrogen concentration through the entire ingot is known in the art, note Ziem et al (US 4,591,409).

Referring to claims 8, Graef et al teaches a nitrogen concentration of $3x10^{14}/cm^3$ and an oxygen concentration of $9x10^{17}$ (col 5, ln 45-60) which is within the claimed range. Graef et al

does not teach the oxygen concentration and the nitrogen concentration are adjusted in a manner that the oxygen concentration and the nitrogen concentration have a predetermined correlative relationship of the nitrogen concentration increase corresponding to the oxygen concentration decrease and the nitrogen concentration decrease corresponding to the oxygen concentration increase such that the epitaxial silicon wafer has sufficient gettering sites. Graef et al teaches doping the single crystal with nitrogen in terms of the defect size distribution must also be considered in connection with the doping of the single crystal with oxygen and for the same nitrogen doping. Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Graef et al by optimizing the oxygen concentration in relation to the nitrogen concentration to obtain same by conducting routine experimentation of result effective variables because a connection with the oxygen concentration to the nitrogen concentration is known. The fact that applicant has recognized another advantage which would flow naturally from following the suggestion of the prior art cannot be the basis for patentability when the differences would otherwise be obvious. See *Ex parte Obiaya*, 227 USPQ 58, 60 (Bd. Pat. App. & Inter. 1985).

Referring to claim 9, claim 9 recites the oxygen concentration is controlled corresponding to a change in the nitrogen concentration, which is a method limitation in a product claim and does not further limit the product claim.

14. Claims 4-5, 8-9 and 35-41 are rejected under 35 U.S.C. 103(a) as being unpatentable over Tamatsuka et al (US 6,162,708).

Tamatsuka et al teaches an epitaxial silicon single wafer characterized in that a silicon single crystal ingot which nitrogen is doped to a concentration of $1x10^{10}$ to $5x10^{15}$ atoms/cm^3 is grown by the Czochralski method and the resultant silicon single crystal ingot is sliced to produce a silicon single crystal wafer (col 2, ln 1-67). Tamatsuka et al also teaches the oxygen concentration is 18 ppma ($9x10^{17}$ atoms/cm3) or less (col 4, ln 1-25).

Tamatsuka et al does not teach the range of nitrogen concentration and oxygen concentration falls within an area in a graph in which the oxygen and nitrogen concentrations are plotted along the horizontal axis and vertical axis of the graph, respectively, on or below a straight line connecting a point at which the nitrogen concentration is $3x10^{15}$ atoms/cm^3 when the oxygen concentration is $7x10^{17}$ atoms/cm^3 and a point at which the nitrogen concentration is $3x10^{14}$ atoms/cm^3 when the oxygen concentration is $1.6x10^{18}$ atoms/cm3. Graef et al teaches the effect of doping the single crystal with nitrogen in terms of defect size distribution must also be considered in connection with the doping of the single crystal with oxygen and for the same nitrogen doping, the proportion of small defects increases as the oxygen doping decreases (col 3, ln 40-45), this is a teaching that the relationship between the oxygen and nitrogen doping concentration is a result effective variable. Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Tamatsuka et al by optimizing the nitrogen and oxygen concentration to obtain same by conducting routine experimentation of result effective variables to minimize large defects. Furthermore, the selection of reaction parameters such as temperature and concentration is obvious (In re Aller 105 USPQ 233, 255 (CCPA 1955)).

Tamatsuka et al also teaches oxygen and nitrogen concentration, which overlap the claimed ranges. Overlapping ranges are held to be *prima facie* obvious (MPEP 2144.05).

Referring to claim 4, Tamatsuka et al does not teach the nitrogen concentration increase gradually from a shoulder portion to a tail portion of the silicon single crystal ingot whereas the oxygen concentration decreases gradually from the shoulder portion to the tail portion. However, this feature is inherent to doped crystals pulled using the Czochralski method, as evidenced by Applicant's disclosure. Applicant's teach that when a silicon ingot is pulled from a silicon melt, unless the oxygen concentration, etc., is deliberately controlled, fluctuation of the nitrogen concentration caused by nitrogen segregation and fluctuation of the incorporated oxygen concentration resulting in a gradually increasing nitrogen concentration and a gradually decreasing oxygen concentration, note page 6, lines 15-25 of the instant specification. Tamatsuka et al does not teach any deliberate control of the oxygen or nitrogen concentration during the pulling process; therefore the gradually increasing nitrogen concentration and gradually decreasing oxygen concentration is inherent.

Referring to claim 5, Tamatsuka et al does not teach the nitrogen concentration in the tail portion is set less than $3x10^{15}$ atoms/cm^3. Tamatsuka et al teaches pulling a silicon ingot using the Czochralski method, which inherently includes a tail region, with a nitrogen concentration of less than $5x10^{15}$ atoms/cm^3 (col 2, ln 30-40), which overlaps the claimed range. Overlapping ranges are held to be *prima facie* obvious (MPEP 2144.05).

Referring to claims 6-7, Graef et al teaches a nitrogen concentration of $3x10^{14}$/cm^3 and an oxygen concentration of $9x10^{17}$ (col 5, ln 45-60) which is within the claimed range. Graef et al does not teach the oxygen concentration and the nitrogen concentration are adjusted in a manner

that the oxygen concentration and the nitrogen concentration have a predetermined correlative relationship of the nitrogen concentration increase corresponding to the oxygen concentration decrease and the nitrogen concentration decrease corresponding to the oxygen concentration increase such that the epitaxial silicon wafer has sufficient gettering sites. Graef et al teaches doping the single crystal with nitrogen in terms of the defect size distribution must also be considered in connection with the doping of the single crystal with oxygen and for the same nitrogen doping. Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Graef et al by optimizing the oxygen concentration in relation to the nitrogen concentration to obtain same by conducting routine experimentation of result effective variables because a connection with the oxygen concentration to the nitrogen concentration is known. The fact that applicant has recognized another advantage which would flow naturally from following the suggestion of the prior art cannot be the basis for patentability when the differences would otherwise be obvious. See *Ex parte Obiaya*, 227 USPQ 58, 60 (Bd. Pat. App. & Inter. 1985).

Referring to claim 9, claim 9 recites the oxygen concentration is controlled corresponding to a change in the nitrogen concentration, which is a method limitation in a product claim and does not further limit the product claim.

15. Claims 22 and 25-29 are rejected under 35 U.S.C. 103(a) as being unpatentable over Wijarankula (US 5,961,713) in view of Graef et al (US 5,935,320) or Tamatsuka et al (US 6,162,708) as applied to claims 1-18 and 30-41 above, and further in view of Hakomori (JP 11-

90803 A), where US 6,261,160 is used as an accurate translation, or in view of Hakomori (US 6,261,160).

The combination of Wijarankula and Graef et al or the combination of Wijarankula and Tamatsuka et al teach all of the limitations of claim 22, as discussed previously, except grinding the silicon wafer substrate.

Hakomori teaches a silicon wafer generally has its periphery chamfered to prevent chipping of its edge and crown during epitaxial growth and the chamfering is done by polishing the wafer with a diamond grindstone ('160 col 1, ln 10-55), this reads on applicant's grinding. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Wijarankula and Graef et al or the combination of Wijarankula and Tamatsuka et al by grinding the wafer prior to epitaxial growth to prevent chipping, as taught by Hakomori.

Response to Arguments

16. Applicant's arguments with respect to claims have been considered but are moot in view of the new ground(s) of rejection.

17. Applicant's arguments filed 9/14/2005 have been fully considered but they are not persuasive.

In response to applicant's argument that the examiner's conclusion of obviousness is based upon improper hindsight reasoning, it must be recognized that any judgment on obviousness is in a sense necessarily a reconstruction based upon hindsight reasoning. But so

long as it takes into account only knowledge which was within the level of ordinary skill at the time the claimed invention was made, and does not include knowledge gleaned only from the applicant's disclosure, such a reconstruction is proper. See *In re McLaughlin*, 443 F.2d 1392, 170 USPQ 209 (CCPA 1971).

In response to applicant's arguments against the references individually, one cannot show nonobviousness by attacking references individually where the rejections are based on combinations of references. See *In re Keller*, 642 F.2d 413, 208 USPQ 871 (CCPA 1981); *In re Merck & Co.,* 800 F.2d 1091, 231 USPQ 375 (Fed. Cir. 1986). Graef et al teaches a silicon single crystal with nitrogen and slicing to form wafers (col 2, ln 40-50). Wijarankula teaches forming an epitaxial wafer from a silicon single crystal wafer without limiting the type of wafer which can be used. Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Wijarankula with Graef's wafer because Graef's wafer has a low density of defects.

Applicant's argument regarding Tamatsuka are noted but are not found persuasive. Tamatsuka teaches $9x10^{17}$ atoms/cm^3 or less, as discussed in the rejection. The claim is for $9x10^{17}$ atoms/cm^3 or higher, which includes the endpoint. Overlapping ranges are held to be obvious (MPEP 2144.05).

Applicant's argument that claim 32 would not have been obvious to a person skilled in the art is noted but is not found persuasive. This argument is viewed as mere attorney argument, which lacks evidence; therefore is not found persuasive. There is clear motivation from the prior art suggesting the combination.

Applicant's argument that the prior art does not teach the nitrogen-oxygen ranges is noted but is not found persuasive. The prior art teaches a range of nitrogen and a range of oxygen which overlaps the claimed ranges; therefore it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the prior to obtain the claimed ranges because optimization of concentrations is held to be obvious (MPEP 2144.05).

Conclusion

18. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Krishna et al (US 5,571,373) teaches polishing a semiconductor wafer to reduce LPDs to about 7 per wafer (col 7, ln 30-67).

Kobayashi et al (US 6,245,311) teaches a heat treatment to obtain a silicon wafer having the number of LPDs not less than 0.12 micrometers of 20 COPs/8 inch wafer (col 11, ln 1-50).

Wilson et al (US 6,284,384) teaches a correlation between atoms/cm3 of oxygen to ppm, where 9×10^{17} atoms/cm3 is equivalent to 18 ppm (col 8, ln 60-67 and col 9, ln 1-15) and a wafer with defects of 0.12 micrometers is less than $0.5/cm^2$ (col 16).

Ziem et al (US 4,591,409) teaches producing a single crystal silicon from a melt while controlling the nitrogen and oxygen concentration by circumventing the segregation coefficients (Abstract).

19. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Matthew J. Song whose telephone number is 571-272-1468. The examiner can normally be reached on M-F 9:00-5:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Duane Smith can be reached on 571-272-1166. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Matthew J Song
Examiner
Art Unit 1722

MJS
November 27, 2005

ROBERT KUNEMUND
PRIMARY EXAMINER